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Some Observations on the Role of Component Size in Solder Joint Degradation under 1 hermal Cycling Environments

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ABSTRACT: Experimental results will be presented from a continuing investigation into the influence of component size and configuration on thermal cycling lifetimes, observed in a set of quadpak electronic component packages. Observed data will be presented from three sizes of Leadless Chip Carriers (LCCs).

Results display qualitative agreement with the generally expected inverse relationship between cycles to joint failure and size of the component, for large components (68 pin quadpaks) and for small sized components (20 pin quadpaks). The number of cycles to failure for the large quadpaks is approximately 1/7 of its counterpart for the 20 pin quadpaks, whose sizes are in the ratio 3.3 to 1. However, the cycles to failure for 28 pin quadpaks are indistinguishable from those of the 20-pin quadpaks, despite the factor of 1.4 between their dimensions.

I. DESCRIPTION OF THE PROBLEM

In general, solder joint lifetimes of electronic hardware are expected to scale as the inverse of linear dimensions of the components[1]. 1 his expectation is based upon the assumption that the force driving the solder degradation mechanism is in proportion to the differential coefficient of thermal expansion for the major materials of the structure involved, in this case ceramic and the printed wiring board.

1 he differential expansion depends directly upon the linear dimensions of the electronic components. Hence, the larger the components, the larger the individual strains during each thermal cycle, the faster the degradation of the solder joints, and the fewer the cycles in the lifetime of the hardware.

This expectation was supported by a set of observations made in a recent experiment. The experimental investigation subjected samples of test articles to the same thermal cycle.

1 his thermal cycle is shown in Fig 1, (1) starting from room temperature and cooling to a minimum temperature of -55 °C, at a ramp rate of about 2 °C per minute, (2) followed by a low temperature dwell at -55 “C for about 30 minutes, (3) followed by heating at the ramp rate of about 2 “C per minute to a maximum temperature of 100 °C, (4) followed by a high temperature dwell at 100 °C for about 30 minutes, and then (5) finishing with a cooling to room temperature, again at a ramp rate of about 2 “C per minute. Allowing for a thermal lag of the test articles behind our ovens of about 15 minutes on each leg, this resulted in a thermal cycle of period 246 minutes, allowing ample time for creep at the high temperature dwell.

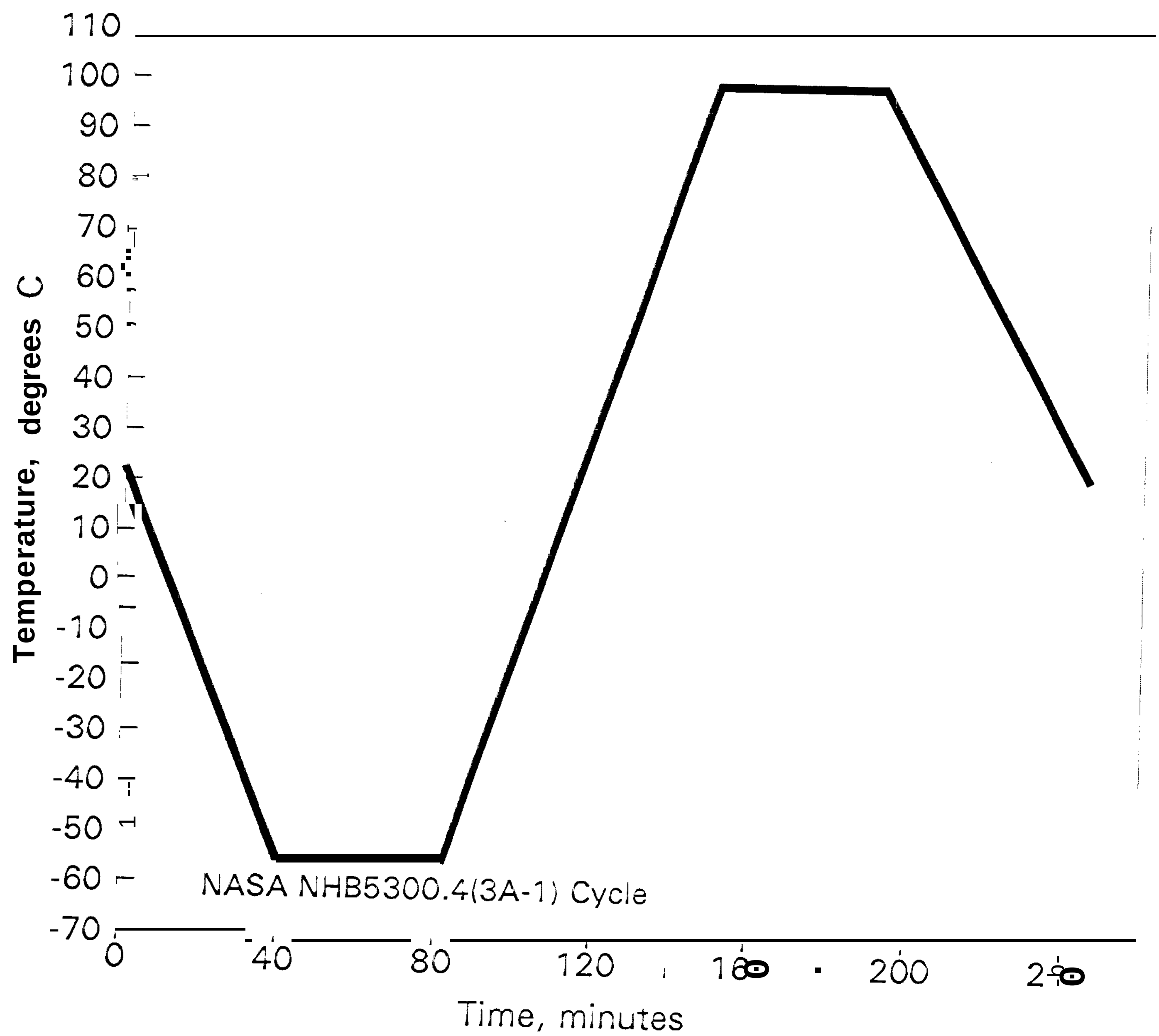
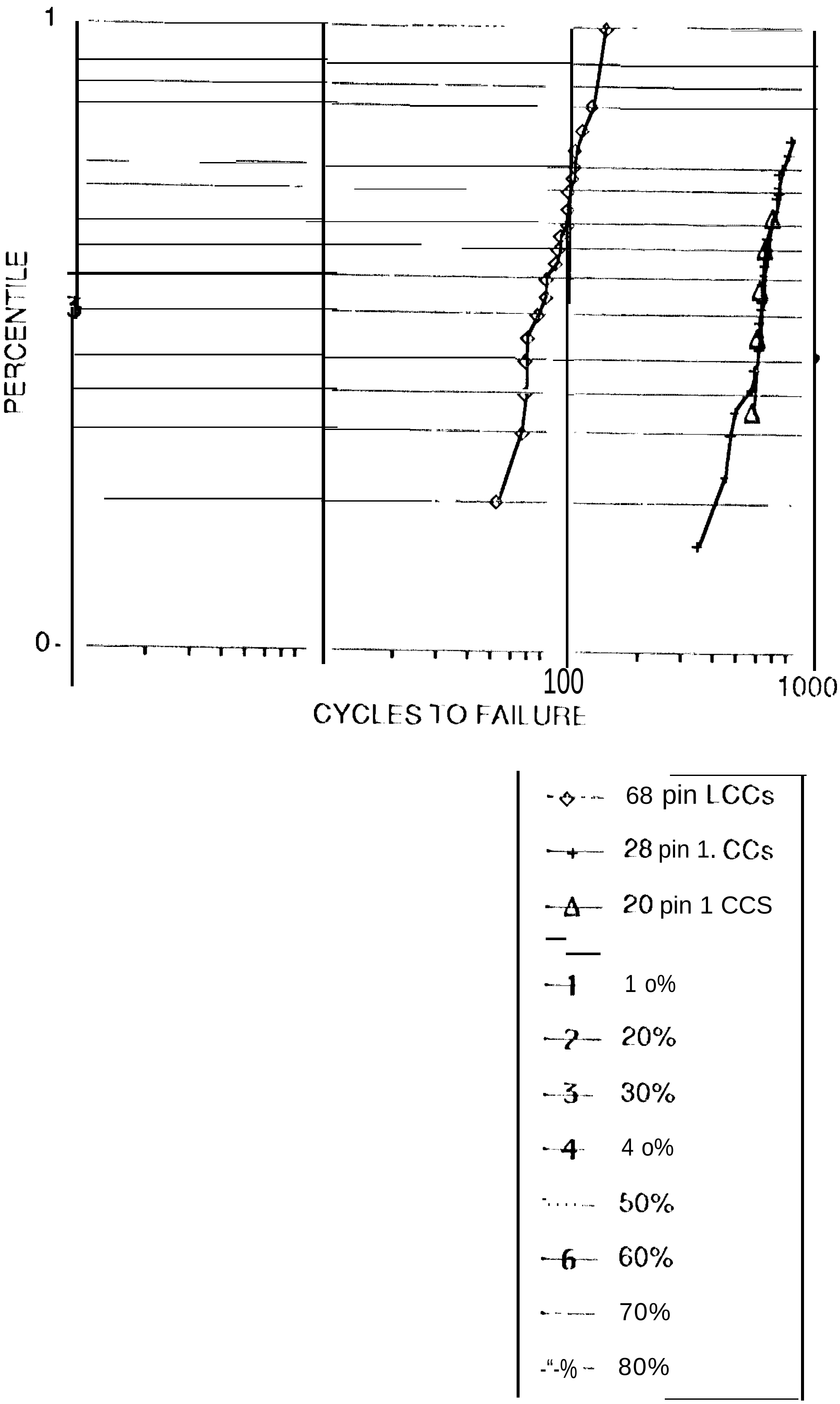


Figure 1 Temperature Cycle Profile

1 he first sample consisted of 30 specimens of 86-pin quadpak LCCs. These dummy packages had corner lead pads separated by approximately 33 mm between pad centers (diagonally). Specimens were reflow soldered to footprints on G10 PWBs. No conformal coating was applied to these specimens,

Leads of each specimen were partially daisy-chained. Failure was defined by loss of electrical continuity along the daisy chain of each specimen. Failure statistics are shown by the Weibull plots of Fig 2.

FIG ?



1
0 -
PERCENTILE
100
1000
CYCLES TO FAILURE
68 pin LCCs
28 pin 1. CCs
20 pin 1 CCS
1 o%
20%
30%
4 o%
50%
60%
70%
80%

The second sample consisted of 8 specimens of 20-pin quadpak LCCs. These dummy packages had corner lead pads separated by approximately 10 mm between pad centers (diagonally). Specimens were reflow soldered to footprints on GI O PWBS. No conformal coating was applied to these specimens.

Package leads of each specimen were partially daisy-chained. Failure was defined by loss of electrical continuity along the daisy chain of each specimen. The 68 pin packages are approximately 3.3 times the size of the 20-pin packages. Failure statistics for the 20-pin quadpak LCCs are shown also in the Weibull plots of Fig. 2.

It will be noted that the 20-pin quadpaks have lifetimes about 7 times those of the 68-pin quadpaks.

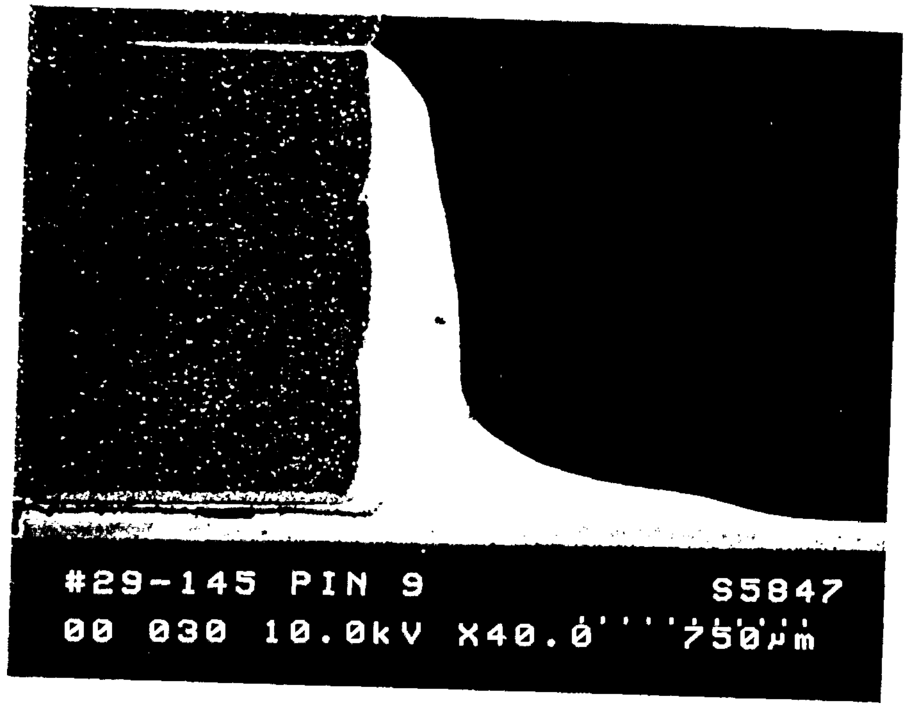
The third sample consisted of 31 specimens of 28-pin quadpak LCCs. These packages had corner lead pads separated by approximately 14 mm between pad centers (diagonally). Specimens were reflow soldered to footprints on G1 O PWBs. No conformal coating was applied to these specimens.

Package leads of each specimen were partially daisy-chained. Failure was defined by loss of electrical continuity along the daisy chain of each specimen. Failure statistics of the 28-pin quadpak LCCS are shown also in the Weibull plots of Fig. ?.

It will be noted that the lifetimes of the 28-pin LCCs are indistinguishable from those of the 20-pin LCCs. This result was inconsistent with the behavior expected for LCCs, and led to further investigation.

II. APPROACH TO FURTHER INVESTIGATION

During visual inspection ot the specimens, it was noted that the individual solder joints for the 20-pin specimens and the 68-pin specimens seemed to be a bit skinnier than those for the 28-pin specimens. Accordingly, a number of the specimens were selected for cross-sectioning of their solder joints. SEM photographs of these cross sections were prepared, with results as shown in Figs. 3A to 3C.


#29-145 PIN 9
S5847
00 030 10.0kV X40.0 750µm

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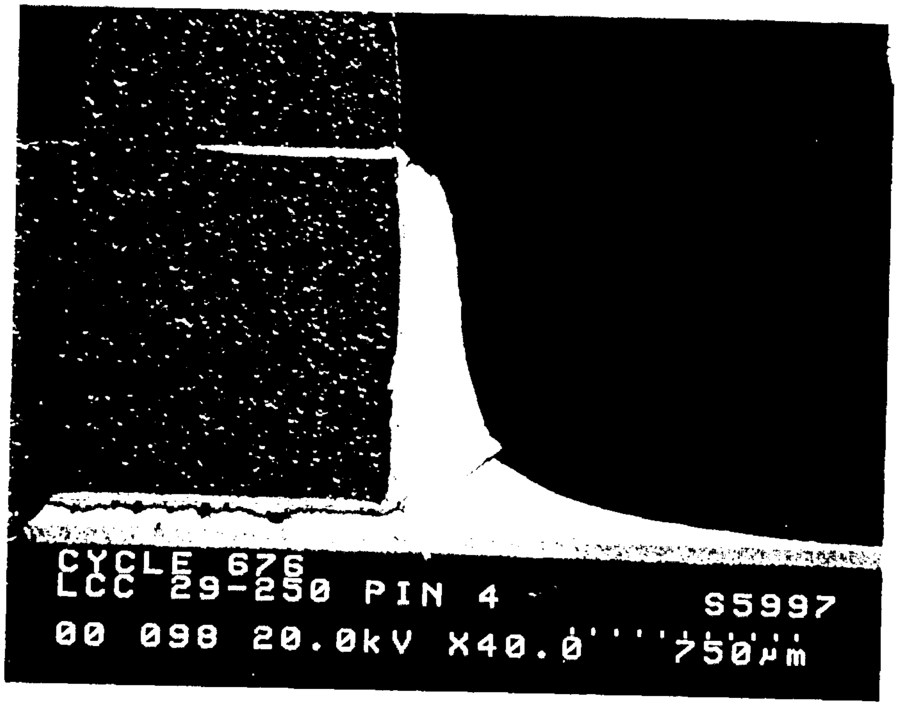

Fig 4b 20 pin LCC

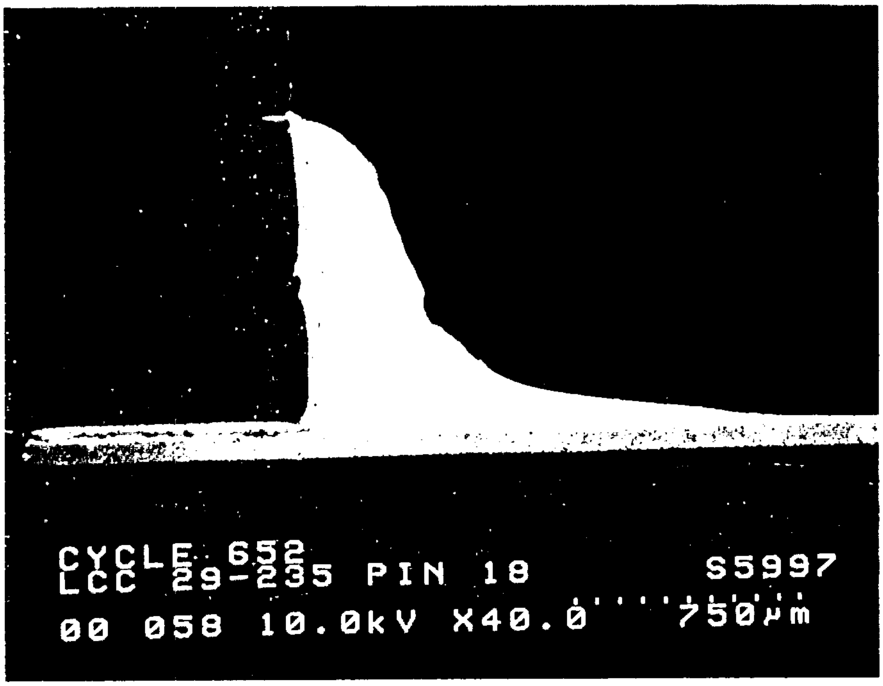

Fig 3C 28 pin LCC

III. EXPERIMENTAL RESULTS

It will be noted that the cross-sections for the 28-pin solder joints are distinctly wider, than those for the 20-pin and 68-pin specimens. Specifically, we take as a measure of joint thickness the distance from the the base of the component, drawn parallel to the PWB, to the intersection with a line drawn at 45° to the land and through the nearest point of the solder meniscus. This measure is 23 mm for the 68-pin LCC and the 20-pin LCC, and 32 mm for the 28-pin LCC, drawn directly on the SEM photo. In terms of actual distances on the specimens, these correspond to 22 roils and 32 roils, respectively.

IV. DISCUSSION AND CONCLUSIONS

If we assume that solder joint life is directly proportional to thickness of the solder joints, and inversely proportional to component dimensions, we see that in comparing the 28-pin 1 CCS to the 20-pin LCCs, the dimension factor is 10/14 $\approx$ 1/1 .4, while the thickness factor is 32/22 $\approx$ 1.45. For all practical purposes, they very nearly cancel each other out, and thus the 28-pin and 20-pin LCCs failure statistics should be indisdinguishable from each other.